12 January 1970

DEVELOPMENT OBJECTIVES

BASIC RESEARCH IN PRECISE MEASUREMENT

1. Introduction - These objectives describe the background, concept and requirements of a government sponsored program of basic research in precise measurement as it relates to mensuration equipment in the imagery exploitation processes.

2. Background - The design of measuring systems used in the exploitation of reconnaissance imagery utilize many different approaches and employ a wide variety of instrumentation to obtain the measured value. The basic characteristic of the measuring instruments may be optical, mechanical, electronic, or any combination of these. The measuring systems may incorporate high performance optical systems, special illumination sources, and may require sophisticated environmental control.

Whatever the nature of the imagery mensuration problem may be, intelligent development, selection and use of measurement techniques and equipment depends on a broad knowledge of what is available and how the performance of the measuring equipment may be described in terms of the mensuration task to be accomplished. Both the new equipment under development and the basic instruments in use can be used as devices for the presentation and development of the general techniques and principles needed in measurement instrumentation. In general, the concepts developed in basic research of precise measurement will be useful in treating any mensuration devices that may be developed in the future.

3. Concept - This basic research program is directed toward the investigation and development of principles, techniques and instrumentation necessary to achieve the precision required in the imagery mensuration process. The research is to be concerned with investigating the factors affecting the standard of measurement, the types of instrument used for measuring, and the environment in which the measurements are made.

The program will not delve into the factors affecting the person making the measurements or the evaluation of specific computer data reduction programs.

4. General Description - The objective of this research program is: to investigate the basic conditions and circumstances that influence the accuracy and precision of measuring engines, to analyze film characteris-

ties as they apply to the mensuration problem, and to generate specifications to be incorporated into development of future mensuration equipment.

The goal of this basic research is to obtain reliable information and recommendations as to improving and developing measurement systems commensurate with proposed acquisition systems and intelligence requirements.

This goal will be accomplished through: a literature search, an investigation of instrumentation requirements, the creation of analytical and experimental models, and a limited amount of breadboarding.

5. Detailed Objectives

5.1 Review of Previous Work and Literature

5.1.1 Review the results of the several related research programs that have been sponsored by the Government. Typical examples of these programs that have been recently completed or are presently underway are as follows:

5.1.1.1 Automatic Stereo Scanning
5.1.1.2 In-House Precise Measurement Study
5.1.1.3 Image Analysis
5.1.1.4 Precision Stereo Comparator

5.1.2 Perform an intensive literature search of available information on dimensional metrology, measuring engines, environmental control, vibrations dampening, light sources, etc. as it may be applied to measurements in imagery exploitation.

5.2 Review Present Mensuration Systems and Equipment

5.2.1 The effect of viewing systems upon the mensuration process.

5.2.1.1 Anamorphic effects
5.2.1.2 Field of view
5.2.1.3 Effect of curvature of field
5.2.1.4 Effect of viewing through film base
5.2.1.5 Magnification vs accuracy of measurement

5.2.2 The effect of viewing illumination on the mensuration process.

5.2.2.1 White light as opposed to near monochromatic light
5.2.2.2 General vs high intensity spot
5.2.2.3 Effects of the amount of light at the eye, the color temperature, etc. on the accuracy of measuring and precision of pointing.

5.2.3 Study film hold down systems and determine their effects upon measurements.

5.2.3.1 Vacuum hold down systems, porous glass, grid pattern of channels, etc.
5.2.3.2 Glass plate hold down, thickness required, loss in resolution and contrast.
5.2.3.3 Clear Plastic Membrane with vacuum header.
5.2.3.4 Film Chip Hold down systems.

5.2.4 Film dimensional changes while on the mensuration equipment.

5.2.4.1 Changes in duplicate positive film over small areas (0.5 um).
5.2.4.2 Changes caused by the film hold down system.
5.2.4.3 Changes caused by the film transport system.
5.2.4.4 Changes caused by the lighting and film cooling system.

5.2.5 Measuring engine accuracy attainable with:

5.2.5.1 Shaft encoders
5.2.5.2 Linear Scales
5.2.5.3 Interferometers
5.2.5.4 Other measuring systems

5.2.6 Investigate type of reticles in use on monoscopic and stereoscopic measuring instruments.

5.2.6.1 Cross hairs, point light sources, black dots, colored reticles, etc.
5.2.6.2 Determine the most desired reticle size as referenced to the film plane.
5.2.6.3 Review the effect of positioning the reticle at various positions in the optical train.

5.2.7 Operator controls in pointing for monoscopic and stereoscopic measurements.

5.2.7.1 Handwheels, joystick, track balls, airbearing carriages, etc.
5.2.7.2 What is best for various degrees of precision (0.1, 0.5, 1.0, 2.5 um)?
5.2.7.3 Operator pointing vs auto correlation.

5.2.8 Evaluate Data Readout Control Modules

5.2.8.1 Performance and requirements
5.2.8.2 Recommendations and specifications for existing and planned mensuration equipment.

5.2.9 Appraise the optical system, the measuring engine, the operator controls, the viewing illumination, etc. as an integrated package in relation to the measuring task to be performed.

5.3 Investigate the Mensuration Requirements as Related to Proposed Imagery Systems

5.3.1 Determine what changes in measurement instrumentation and techniques will be required to accommodate color photography.

5.3.1.1 Recommendations as to light sources and color temperature.

5.3.1.2 Viewing systems performance on color imagery. Will there be a depth of focus problem at higher magnification?

5.3.1.3 What is the best method of holding this imagery flat against the film platen?

5.3.1.4 What are the limitations of a stereo correlation unit on color imagery?

5.3.1.5 Specify the modifications that could be made to existing mensuration equipment to adequately handle color imagery.

5.3.1.6 Can additive color or false color be used for precise mensuration.

5.3.1.7 Define the specifications that should be included in future mensuration equipment for color imagery.

5.3.2 Investigate the mensuration techniques that might be used on near real-time systems.

5.3.2.1 What are the problems involved in obtaining monoscopic and stereoscopic measurements from a vidicon type display?

5.3.2.2 What accuracies are attainable?

5.3.2.2.1 Is it acceptable for precise photogrammetric type measurements?

5.3.2.2.2 Is it suitable for comparative type measurements?

5.4 Environmental Control Required for Precise Measurement and Comparative Measurements

5.4.1 Temperature and humidity control required for film stability.

5.4.2 Temperature, humidity and vibration control required for measuring and viewing.

5.4.3 Heat problems caused by high intensity light sources.

5.4.4 Temperature and humidity control required on compressed air used for film cooling and air bearing stages.

5.5 Evaluate Film Base and Emulsion Stability as to:

5.5.1 Roll film vs chip storage

5.5.2 Sheet processing of duplicates for mensuration vs standard Niagria processing.

5.5.3 Measuring accuracy on original negative, first positive, etc.

5.5.4 Mensuration results on dry silver processed positive transparencies vs standard wet process.

6. Technical Requirements - It is realized that the complexity and emphasis will vary and be shifted with the findings of the basic research. The Objectives listed on Section 5 are very broad and within these areas the contractor will perform the following:

6.1 Provide consultation to the Government in the precise measurement field.

6.2 Have an expert awareness of past and present research in this field so as to prevent duplication.

6.3 Have the capabilities to undertake studies to determine the most desirable mensuration procedure for a task.

6.4 Be capable of undertaking practical experimentation as well as the theoretical approach on imagery measuring problems.

6.5 Be capable of determining the dynamic range capabilities and limitations of possible systems utilizing film inputs.

6.6 Conduct studies to determine the sub systems that require a major research effort.

6.7 Determine weak links in the mensuration process.

6.8 Generate Design Specifications that should be incorporated into immediate and future mensuration equipment.

6.9 Prepare Cost vs. Performance Curves for various mensuration tasks, instruments, and the degree of precision required.

7. Areas of Investigation

7.1 The contractor will be able to obtain a great deal of information from the technical literature and government research programs referred to in Paragraph 5.1. The contractor will be expected to digest and present this information in a manner so that it can be implemented in future mensuration systems.

7.2 The contractor will have to supply his own photogrammetrists and interpreters for any tests and experiments he plans to perform. It is possible that some time on the Government's measuring instru-

ments could be provided the contractor, however, it is recommended that he plan on supplying the majority of the instrumentation required on any tests.

7.3 The contractor is encouraged to undertake a limited amount of experiments, tests, and breadboarding in order to demonstrate any significant findings or breakthroughs.

7.4 The contractor will make recommendations as to improving mensuration techniques, equipment, and subsystems with the prospects for high payoffs:

7.4.1 Immediately
7.4.2 In the Near Future
7.4.3 In Long Range Mensuration Planning

7.5 The contractor is expected to supply recommendations, test results, and specifications as to pushing the state-of-the-art in developing mensuration equipment and procedures to extract the maximum data from the imagery, however he must primarily consider procedures to make the mensuration process more efficient, faster, and less costly while relieving the operational personnel of the drudgery and monotony of performing routine tasks.

8. Miscellaneous

8.1 Level of Effort - The available FY-1970 funding for this project is very limited, therefore, the areas to be investigated have been restricted to the most pertinent problem areas. The contractor will submit a plan to accomplish the research over several years funding and the emphasis for FY-1970 funding will be in the following priority areas: Color Mensuration/Comparators, evaluation of data readout control equipment, film dimensional changes on the comparators, reticle and reticle position, and automatic pointing.

8.2 Proposals - The potential bidders are required to review the objectives and to isolate the areas they feel are most productive. The bidder's proposal will break the productive areas down into tasks and each task will be priced out separately in the proposal. The proposals should be comprehensive, well organized, explicit, clear, concise, and limited in content to that information required to qualify the prospective bidder and demonstrate ability to perform satisfactorily within the scope of this document. The format of the proposal should be arranged as to conform with the outline on the attached sheet titled "PROPOSAL FORMAT".

8.3 Administration - The Government will retain overall control of this program. Written approval from the contracting officer must be obtained before any changes in objectives, costs, or priorities are effected or before any subcontractor or consultant is employed.

8.4 Contractor Responsibility - The contractor is expected to provide competent and cooperative administrative service. He will be vested with certain authority to control the direction and degree of technical effort within the bounds of the estimated costs. As a part of his overall responsibility, the contractor will be responsible for the work performed by all of his subcontractors and consultants. The fact that the Government has granted approval of the use of a specific subcontractor or consultant (see Paragraph 8.3) in no way relieves the contractor from this responsibility.

8.5 Technical Representatives - The contracting officer will designate a technical representative to authorize specific development efforts of the contractor. Such authorization shall be given in writing in its original form or in confirmation of an oral authorization. The contractor will accept no other authorization except that of the technical representative or contracting officer.

8.6 Reports - Regular reports will be required throughout the life of the contract. All reports will meet the basic requirements of specification DB-1001, dated 31 August 1966, GENERAL REQUIREMENTS FOR CONTRACTUAL DOCUMENTATION, attached hereto.

PROPOSAL FORMAT

All Proposals Must Include the Following Information:

I. Task Abstract: Contents - Synopsis of task within 12 lines, plus estimated cost of direct labor, material, overhead, G&A, fee, total.

II. Introduction: Contents - Covering background and task justification rationale.

III. Technical Discussion: Contents - Detail and subsections as a function of the task.

IV. Work Statement: Contents - This statement should succinctly describe the individual tasks to be done and should be sufficiently definitive that one may read this section to understand the purpose and scope of the tasks.

V. Deliverable Items: Contents - 1) Interim and Final reports
2) Equipment

VI. Schedule of the project percentage of completion of performance by months and related schedule of percentage of project expenditures by month in tabular form.

VII. Time Bar Chart

VIII. Financial Considerations: Contents - Cost details, summary, GFE required.

CONTRACTUAL DOCUMENTATION TO BE SUPPLIED BY CONTRACTORS

1. SCOPE

1.1 This Specification covers the contractual documentation to be supplied by contractors in the performance of Research and Development contracts.

2. REQUIREMENTS

2.1 General - In order to maintain proper control the progress and funding of Research and Development contracts, it is necessary that certain orderly reporting be accomplished by the Contractor on a regularly scheduled basis.

2.1.1 All documentation submitted by the Contractor shall bear the control number assigned by the Contracting Officer's Technical Representative. This control number shall appear on all correspondence, reports, etc., submitted by the contractor under the contract.

2.2 Types of Reports - The following types of reports shall be submitted by the contractor. Specific reports shall include, but not necessarily be limited to, the designated information.

2.2.1 Monthly - A monthly report shall be prepared as of the last working day of each calendar month. The first monthly report shall be prepared as of the last working day of the first full calendar month subsequent to the date of contract. Monthly reports shall be mailed so as to reach the consignee(s), stated in the contract, not later than the first business day after the fifteenth of the month following the reporting period. Each Monthly report shall provide the following, with negative reporting if applicable.

2.2.1.1 A statement of the activity on the project during the month and the percentage of work completed as of the reporting date.

2.2.1.2 A statement of the planned activity for the next month.

2.2.1.3 A statement of pending, unresolved technical problems.

2.2.1.4 A statement of pending, unresolved contractual problems.

2.2.1.5 A statement for the record, of agreements or understandings reached orally during the reporting period on technical matters not requiring the approval of the Contracting Officer.

2.2.1.6 A statement of any proposed change, agreement or understanding which requires the approval of the Contracting Officer. The contractor is cautioned not to proceed in a situation requiring the prior approval of the Contracting Officer until such approval has been obtained. In situations requiring correspondence with the Contracting Officer, a complimentary copy shall be forwarded, simultaneously, directly to the Contracting Officer's Technical Representative.

2.2.1.7 A statement of unanswered, unresolved matters, unanswered correspondence, etc., and whether delinquency is attributed to the contractor or to the Government.

2.2.1.8 Status of funds. The format shown in Enclosure 1 shall be used to report the status of funds. All applicable items shall be reported. If no expenditures or obligations have been incurred for a specific item, the word "None" shall be entered in the space assigned for the dollar amount.

2.2.2 Final Report - The final report shall be submitted to the Contracting Officer's Technical Representative on or before the thirtieth day following completion of the work under the contract. This report shall cover the entire design and/or development work accomplished during the period of performance and shall contain a section covering the work performed under each of the tasks set forth in the Work Statements. The report shall state concisely but completely the major problems encountered, the apparent cause of the problems, the problem solutions and an evaluation of the solutions based on actual application of the solutions.

2.2.3 Installation Engineering Data - Whenever hardware is a deliverable item under a contract the contractor shall provide the Installation Engineering Data requested on Enclosure 2. The Contracting Officer's Technical Representative shall provide the blank forms to the Contractor. Preliminary data shall be submitted to the Contracting Officer's Technical Representative at six months and again at three months prior to the delivery date of the equipment. Final data shall be submitted by the contractor not less than thirty days prior to the delivery of the equipment.

2.2.3.1 The outline drawing, submitted with the Installation Engineering Data form shall show:

(a) the orientation of the equipment within the work area for normal equipment useage.

(b) the exact location of all external connections.

(c) the clearance required around the equipment for access to all removeable panels, doors, etc.

(d) the location of mounting points and type of mounting required.

2.3. Delivery of Reports - All monthly reports and the final report shall be forwarded by the contractor to the Consignee(s) specified in the contract. The contractor shall forward each report in the number of copies specified in the contract.

2.3.1 The Installation Engineering Data form plus the outline drawing shall be forwarded to the Contracting Officer's Technical Representative.

Statement of Funds as of 30 September 19XX (See Note 1)

EXPENDITURES

1. Labor:			
a. Total paid as of 31 August 19XX		XX,XXX	
b. Paid during September 19XX		X,XXX	
c. Sub-total			XX,XXX
2. Material:			
a. Total paid as of 31 August 19XX		X,XXX	
b. Paid during September 19XX		XXX	
c. Sub-total			X,XXX
3. Services (sub-contracts, etc.):			
a. Total paid as of 31 August 19XX		X,XXX	
b. Paid during September 19XX		XXX	
c. Sub-total			X,XXX
4. Total expenditures as of 30 September 19XX			XX,XXX

OBLIGATIONS AND ESTIMATES

5. Obligations:			
a. Sub-contract W/ABC Co., amount not yet paid		X,XXX	
b. Sub-contract W/DEF Co., amount not yet paid		XXX	
c. Material ordered but not yet paid for		XXX	
Sub-total			X,XXX
6. Estimates of Future Expenditures:			
a. Estimate of labor required		X,XXX	
b. Estimate of material required		XXX	
c. Proposed sub-contracts		XXX	
Sub-total			X,XXX
Total			XX,XXX

Enclosure 1

NOTES:

1. All amounts shown above must include overhead, G&A, handling charges, fees, etc.

INSTALLATION ENGINEERING DATA

Date form completed _____

(See Remarks at end of form)

Tentative [ ] Valid until _____

Final data [ ]

I. INSTRUMENT
- A. Name of instrument: _____
- B. Manufacturer: _____
- C. Contract number: _____
- D. Delivery date: Tentative: _____ Final: _____

II. PHYSICAL FEATURES
- A. Sub-assemblies:
  1. Number of sub-assemblies: _____
  2. Largest sub-assembly: Weight _____lbs; _____" H x _____" W x _____" D
  3. Heaviest sub-assembly: Weight _____lbs; _____" H x _____" W x _____" D
- B. Assembled instrument:
  1. Number of major components: _____
  2. Largest component: Weight _____lbs; _____" H x _____" W x _____" D
  3. Heaviest component: Weight _____lbs; _____" H x _____" W x _____" D
  4. Total floor space required after assembly, including maintenance access space. ___Ft. ___In. High x ___Ft. ___In. Wide x ___Ft. ___In. Deep.
  5. Total weight of assembled instrument: _____lbs.
- C. Type of base of mount: Flat ____; 3-point suspension ____; 4-point suspension ___
- D. Does the instrument have built-in mobility? Yes ____ No ____
- E. Is the instrument particularly sensitive to vibration? Yes ____ No ____
  Will the instrument generate vibration? Yes ____ No ____
- F. Are any special or unusual tools or fixtures necessary or adviseable for the installation of the maintenance of this instrument? Yes ____ No ____.
  If "Yes," please describe: _____

III. UTILITIES
- A. Electrical:

	AC	DC
1. Voltage	_____Volts / _____Volts	_____Volts / _____
2. Current	_____Amps/phase	_____Amps
3. Frequency	_____cps	
4. Nr. of phases	_____Ph	
5. Nr. of wires	_____	
6. Power required	_____Watts	_____Watts
7. Power factor	_____(Leading) (Lagging)	

8. Type of outlet: Two prong ___; three prong ___; Twist lock ___; Perm.___
9. Type of ground: Building conduit ___; Direct earth ground ____.
10. Should the instrument be shielded, either from external electromagnetic signals or to prevent interference with other equipment? Yes ____No____
    If "Yes," to what extent? _____

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B. Air conditioning:
1. Desired environment: Room air temperature of ___ °F ± ___ °F and relative humidity of ___% ± ___%.
2. Input Air: Is a direct connection necessary? Yes ___ No ___; Adviseable? Yes ___ No ___; If "Yes," what is the connector type and size? _____ Recommended input air temperture ___ °F ± ___ °F. Relative humidity ___% ± ___%. If input air must be filtered, what is the maximum particle size in microns? ___ What particle count? _____/ cu. ft.
3. Output Air: Is a direct connection to the return air duct necessary? Yes ___ No ___. Adviseable? Yes ___ No ___. Connector type and size? _____. Output air temperature ___ °F ± ___ °F. Relative humidity ___% ± ___%. Output heat ___BTU/Hr. Flow of ___CFM. Is output air toxic? Yes ___ No ___; Noxious? Yes ___ No ___.

C. Plumbing:
1. Is water required? Yes ___ No ___; Pressure ___PSIG, flow ___GPM.
2. Type of water required:
Tap ___ °F ± ___ °F Deionized ___ °F ± ___ °F
Tempered ___ °F ± ___ °F Filtered ___ °F ± ___ °F
If filtered, give maximum permissible particle size in microns and the maximum permissible count. _____ microns _____ particles/cu. ft.
3. Pipe required:
Galvanized ___ Copper ___ Size _____
Stainless Steel ___ Plastic ___ Type of connector _____
4. Floor drain:
Diameter of drain ___ Galvanized drain? ___
Plastic drain? ___ Glass drain? ___
5. Are any chemical solutions used in the device? Yes ___ No ___. If "Yes," state the nature of the solution(s), permissible temperature range, flow rate in appropriate units and the filtration necessary for each solution _____.
6. Size of pipes and connectors _____.

D. Compressed air:
Is compressed air required? Yes ___ No ___. Water free? ___ Oil Free? ___
Type and size of connector? _____. Pressure _____PSIG. Flow in CFM
Maximum ___, minimum ___, average ___.

E. Vacuum:
Is vacuum required? Yes ___ No ___. Pressure ___PSIA or (inches of water) (millimeters of mercure). Displacement in CFM, maximum _____, minimum _____, average _____. Type and Size of connectors _____.

F. Peripheral Devices:
Will the instrument be connected to any peripheral devices such as a computer or data input or data output device? Yes ___ No ___. If "Yes," give, in detail, the nature of the connection to the peripheral device such as coaxial cable, multiple wire connector, etc.

IV. REMARKS
A. Use additional sheets if more space is required for environmental conditions or utilities not mentioned above.
B. Submit three typed copies of the completed form to the Technical Representative.

C. Attach three copies of a dimensioned outline drawing of each major component and of the completed assembly. Include the estimated weight of each major component and of the completed assembly. Indicate, on the outline drawing of the completed assembly, the space required for access to the instrument for maintenance.

D. If a question does not apply to the instrument, insert "N/A" (Not Applicable) in the appropriate blank space.

Information provided by:

_____
(Signature)

_____
(Position or job title)